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NIGHT ACTIVITY OF TSETSE (*GLOSSINA*) ON THE KENYA COAST.

By J. Y. Moggridge.

(*Tsetse Research Department, Tanganyika Territory.*)

1. Introduction.

During investigations of the general bionomics of the tsetse of the Kilifi Region on the Kenya Coast north of Mombasa an excursion into the savannah at night led to the chance discovery that *Glossina austeni* Newstead attacked during the hours of darkness. In order to investigate this night activity work was started in February, 1937, and continued until the end of September in the same year. During this period 44 catches were made during the early hours of the morning before daybreak.

2. Technique.

From February to July, 1937, catches were made over a distance of 1000 yards along a path which formed part of a routine fly round in savannah woodland. From July until the night catches stopped in October, 1937, catches were made along a more extensive section of this savannah round. The former catches lasted for 26 minutes on an average and the latter three-quarters of an hour. During April no night catches were made.

In the earlier series of catches no bait cattle were used, but later one or, more usually, two were used. The number of catchers varied between four and five. The writer was present at all catches. Fly nets were not carried.

The method was the same on all occasions. After brief notes on the weather had been recorded at some distance from the starting-point the party moved up the track in single file. On very dark nights progress was slow, but the route was well known and artificial light was never used. As soon as one of the party felt a probe he announced the fact and the rest waited until he had secured his tsetse. At stops like this others were often bitten and the party then waited until the attack had ceased. If no one was bitten within a reasonable time a halt was called to allow the members of the party to close up and to give any following tsetses an opportunity to get to close quarters. Each catcher carried a numbered test-tube in which he placed his catch. Directly after the catch the tsetses were examined and a record was made. Owing to the darkness no instruments could be read at the time of the catch, but recording instruments elsewhere on other fly rounds furnished any information required. The data accruing from the first series of night catches are given in Table I.

3. Behaviour at Night of *G. austeni* Newstead.

The attack of *G. austeni* was silent and very expertly accomplished. The first indication of its presence was a probe. The tsetse almost invariably attacked the legs behind the knees. If disturbed whilst probing it would fly off and return as expertly as in daytime. When bait cattle were used *G.*

austeni did not seem to be attracted to them since the animals did not give their usual indication of being bitten.

TABLE I.—*Record of Captures of* G. austeni *at Night in Savannah.*

1937.	*G. austeni.* ♂.	♀.	Total.	♀♀%	Rate per hour.	Hunger.	Time. From	To	Min.	Remarks.
						Dry season.	hrs.	hrs.		
Feb. 4	18	22	40	55·0	60	Hungry	4.50–5.30		40	Half moon, cloudy, later clear.
„ 5	40	30	70	42·8	120	„	5.00–5.35		35	Half moon, clear sky.
„ 6	19	23	42	54·8	84	„	5.00–5.30		30	Sickle moon, clear sky.
„ 12	12	24	36	66·6	98	„	5.10–5.32		22	Very dark.
„ 13	13	16	29	55·2	53	„	4.37–5.10		33	Very dark and still.
„ 16	23	21	44	47·7	53	„	3.50–4.40		50	Pitch dark.
„ 26	11	10	21	47·6	36	Very hungry	4.10–4.45		35	Full moon, totally obscured.
Mar. 6	28	19	47	40·4	118	Hungry	4.30–4.54		24	Last quarter, clear but hazy.
„ 13	7	9	16	56·2	51	„	4.34–4.53		19	Very dark. Sky overcast.
						Humid season.				
May 18	4	4	8	50·0	20	Not hungry	4.40–5.04		24	Clear sky, stars bright.
„ 29	1	1	2	50·0	8	?	5.05–5.20		15	Sky lighting before dawn.
June 7	5	4	9	44·4	20	Not hungry	4·10–4.37		27	Dark, clear sky.
„ 15	5	0	5	0	17	„	4.25–4.43		18	Dark.
„ 21	2	0	2	0	5	„	3.50–4.12		22	Dark, light rain.
July 21	0	0	0	0	0	„	3.50–4.07		17	Full moon, totally obscured, dark.

The African assistants who took part in the night catches wore khaki blouses and short trousers. In spite of being more conspicuous the writer captured far fewer tsetses than did his assistants. Place in the file made no difference to the catch so far as he was concerned.

Below are given the average percentages of the total catches made by the assistants in the order in which they followed in single file :

No. 1	31%	No. 5	17%
„ 2	25%	„ 6	13%
„ 3	10%		

The writer (No. 4) caught 4%.[1]

On one occasion in the later series of catches the writer after working all day in the field and taking strenuous exercise in the evening took part in a catch at 8.30 p.m. During the day the writer had purposely neither washed nor changed his clothes. On this one occasion the number of *G. austeni* which he captured approximated to the individual catches of his assistants.

During February and March, 1937, when *G. austeni* was displaying maximum night activity, six daylight catches were made over the same ground caught over at night. After completing the catch the party waited on these

[1] A statistical examination of the percentages of the total catch obtained in individual catches of over 10 flies showed that the mean percentage of the total caught by No. 1 was significantly higher than that caught by No. 2 (P = slightly less than 0·05, using the *t* test), and that the mean percentage caught by No. 4 (invariably Mr. Moggridge), though not significantly different from those of either No. 3 or No. 5 taken separately, was significantly different from those of Nos. 2, 3 and 5 taken together; P = less than 0·01, using the *t* test.—W. H. Potts.

occasions until it was fully light and then retraced their steps to the starting-point of the night catch. Bait cattle were not used on these occasions.

The intention of these catches was to ascertain whether the presence of *G. austeni* would be revealed in that same sector in which the tsetses had been offered the opportunity to attack under cover of darkness.

The results of these double catches are set out below in Table II.

TABLE II.—*Catches made in the Savannah during February and March*, 1937, *at Night* (a), *and Return Catches made over the Same Section at First Light* (b).

		G. pallidipes.				*G. austeni.*				Hunger.	Time.		Remarks.
		♂.	♀.	Total.	♀ ♀ %.	♂.	♀.	Total.	♀ ♀ %.		From	To	Mins.	
											hrs.	hrs.		
6/2/37	(*a*)	0	0	0	.	19	23	42	55	Hungry	05.00–05.30		30	3 days past full moon; no cloud.
	(*b*)	0	0	0	.	0	0	0	.	.	06.06–06.20		14	1 *G. austeni* missed; numbers of *G. pallidipes* seen on grass, etc.
12/2/37	(*a*)	1	1	2	50	12	24	36	67	Hungry	05.10–05.32		22	Very dark at first, but perceptibly lighter during last 7 min.
	(*b*)	0	0	0	.	0	1	0	100	.	06.10–06.22		12	*G. pallipides* seen on leaves, etc., but not attacking.
13/2/37	(*a*)	0	0	0	.	13	16	29	55	Hungry	04.37–05.10		33	Very dark and still.
	(*b*)	0	0	0	.	0	0	0	.	.	06.13–06.25		12	..
26/2/37	(*a*)	0	1	1	100	11	10	21	43	V. hungry	04.10–04.45		35	Full moon, totally obscured. 1 *G. brevipalpis* seen.
	(*b*)	0	0	0	.	0	1	1	100	.	06.03–06.16		13	Quite light. No *G. pallidipes* seen.
6/3/37	(*a*)	1	2	3	67	28	19	47	40	Hungry	04.30–04.54		24	1 day past last quarter. Clear sky but hazy.
	(*b*)	0	0	0	.	0	0	0	.	.	06.05–06.16		11	1 *G. pallidipes* seen.

It will be seen that while considerable activity was shown by *G. austeni* when the party passed along in the dark, almost no activity was observed when the party passed over the same route shortly afterwards in daylight. The deduction is made that such *G. austeni* as were present when the party passed up the path in the dark made their attack and were captured. An absence of *G. austeni* on the return catch suggests that there had been no movement of the population during the 56 minutes which, on average, elapsed between the finish of the night catch and the start of the day catch.

4. Factors Inducing Night Activity in *G. austeni*.

During periods of severe dry season conditions it has been shown that this species displays rush activity[2] in the early mornings and thereafter becomes

[2] Rush activity is the term used by the writer to describe the exceptional activity displayed by both *G. pallidipes* and *G. austeni* in the morning during periods of severe dry weather.

quiescent for the rest of the day. This abnormal and concentrated activity is associated with a need to find food before the period of involuntary inactivity sets in. The more severe the physical conditions, the more restricted is the time available for this purpose, and it cannot be doubted that a considerable proportion of the population fails to contact a host. Under normal physical conditions activity is possible at all hours of the day, although all-day catches show that throughout the middle hours activity is low. It is probable that conditions of relatively high temperature and saturation deficit obtaining during the middle hours of the day cause a diminution in activity. It is possible, therefore, that even under moderate physical conditions some members of the population fail to find a host or obtain only a partial feed. The inability to satisfy hunger during daylight hours induces activity at night when, usually, optimum physical conditions prevail, and upon the degree of hunger and the number of individuals affected will depend the degree of night activity.

5. Evidence on Distribution.

As has already been stated, from July to October, 1937, a humid period when tsetses were not displaying rush activity,[3] 16 night catches were made over part of the savannah fly round with two bait cattle. A total of 138 *G. austeni*, 30 *G. brevipalpis* and 15 *G. pallidipes* were captured. Fly nets were used. Of the 138 *G. austeni* captured, 119 were taken on No. 1 and No. 2 sections. No. 1 section showed a total catch of 94, while No. 2 section showed a total catch of 25. These two sections traversed dense savannah, while the remainder were mostly lightly wooded marginal sections. In so far as the marginal sections are concerned the small catches made in them resemble the results of daytime fly rounds.

The preponderance of captures made at night in No. 1 section reverses the usual course of events in catches made during the mornings on these sections. The comparative results obtained from the night and morning catches suggest that *G. austeni* frequents the denser wooding during the night, and searches for food during the day in the adjacent areas of lighter vegetation.

6. Sense used by *G. austeni*.

The late Dr. H. Eltringham, F.R.S., kindly examined a number of heads of *G. austeni*, *G. brevipalpis* and *G. pallipides* from Kilifi. His examination showed the eyes to be of pseudocone type. There was nothing to suggest that the tsetses possessed the power of night vision. He suggested in correspondence that scent might be the sense employed to make contact with a host at night. This is supported by the writer's personal experience cited above.

7. Night Catches with Lamps.

In order to find out whether the tsetses would be attracted to artificial light, three catches were made during the dry season of 1937. The catches were made on No. 1 section of the savannah round; bait cattle were not used.

[3] This is well demonstrated by Table I, which shows 9 catches during the dry period (February–March), averaging 38·4 *G. austeni* per catch, and 6 catches during the humid period May–July), averaging only 4·3.

The catching party consisted of five catchers, and three hurricane lamps were carried. The average time taken on these catches was 20 minutes. The nights on each occasion were dark and there was no moon. A total of ten *G. austeni* was taken on these catches. It would appear that none of the three species of tsetse is attracted to artificial light at night, for as Table I shows, these catches are well below the average caught without lights at the same time of year.

8. Night Activity of *G. brevipalpis* and *G. pallidipes*.

During the catches without lamps 15 *G. pallidipes* and 5 *G. brevipalpis* were caught, and with lamps 1 *G. pallidipes* and 4 *G. brevipalpis*. The majority of *G. brevipalpis* were taken on the cattle. This species had a habit of crawling over the skin of a bait animal and seemed loth to fly away from it. During both the day and the night catches it was possible to capture this fly by placing the palm of the hand over it. At night *G. brevipalpis* appeared to be extraordinarily clumsy. The loud droning of its wings could be heard as it circled round and round the party about two feet (it seemed) above their heads. The insect appeared to be flying blindly, as time and time again it was heard to collide with leaves and branches. Eventually it dived at the party and came into collision with one of them, usually striking the head or shoulders, when it would bounce off and start circling again. *G. pallidipes* seemed almost as expert as *G. austeni* but was heavier, and it could usually be heard in flight. It attacked the legs, especially behind the knees.

9. Acknowledgments.

The writer wishes to express his appreciation of the helpful suggestions given him by Mr. Potts and Dr. Jackson of the Tsetse and Trypanosomiasis Research Organization, Shinyanga, Tanganyika.

10. Summary.

Glossina austeni is active at night at all seasons, but maximum activity at night takes place during the dry season. Rush activity in daytime (activity intensified by compression into a short period) is associated with marked night activity. It is thought that this tsetse suffers from hunger during the dry season on account of its abbreviated period of daytime activity under severe dry season conditions. Restricted daytime activity (but to a much less extent) at other seasons induces night activity in a small proportion of the population which has failed to satisfy its hunger completely in daytime. *G. austeni* attacks on dark nights as readily as on moonlit nights. The attack is expertly executed. It shows a preference for humans as against bait cattle by night, and the presence of bait cattle did not then raise the numbers of this tsetse captured. Of a file of seven persons the leader was attacked to a greater extent than the others. Conspicuous clothing did not attract *G. austeni* at night. Artificial illumination used on dark nights did not attract this tsetse. There is reason for believing that only tsetse resting in the vicinity of the moving party are induced to attack, and that there is no free movement through

wooding at night. The sexes were captured in about equal proportions. Catches made in denser savannah at night were on all occasions larger than those made in adjacent lighter savannah wooding. There was some indication that smell may play a part in attracting this species at night.

Small captures of *G. pallidipes* and the occasional capture of *G. brevipalpis* were made, but these appeared to be purely fortuitous. Neither species was attracted to artificial light. *G. brevipalpis* was clumsy, and evidently could not see in the dark, as it frequently collided with vegetation.

The eyes of all three species were examined in England by the late Dr. Eltringham. They showed no special ability to see in the dark.

Book Notices.

Indexed Check-List of the British Lepidoptera with the English Name of each of the 2313 *Species.* By I. R. P. Heslop, M.A., F.R.E.S. 85 pp. 8vo. Published for the author by Watkins & Doncaster, London. 1947. Price 4s.

This list is really a new edition of the 1945 check-list, and in compiling it the author has taken the opportunity of making some additions and corrections. Superfamilies, families and sub-families are clearly set out as main headings, under which the species are numbered consecutively, the English names being given in a parallel column.

There is an index of scientific and of English names, and an appendix in which the English names used by Kirby and in the latest edition of South are tabulated for easy comparison.

Insects and Human Welfare. An Account of the More Important Relations of insects to the Health of Man, to Agriculture and to Forestry. By Charles T. Brues. Revised edition. 8vo. Harvard University Press (London: Geoffrey Cumberlege), 1948. Pp. xiv + 154, 14 figs. Price 14s.

Since the first edition of this work appeared in 1920, and especially since the second world war, great advances have been made in the methods of insect control, and the present edition has been revised in the light of these developments. The book deals with insects as carriers of disease, as enemies of agriculture, and of forestry, and as nuisances in the household, with observations on the various methods of control.

Simple Experiments with Insects. By H. Kalmus. 8vo. London: William Heinemann, Ltd., 1948. Pp. xii + 132, text illust. Price 7s. 6d.

This book is an introduction to the fields of insect behaviour and physiology, and describes experiments that can be carried out with very little apparatus.

It caters for both the amateur naturalist and the student of biology, and includes full instructions for each experiment, and many illustrations. A bibliography and index complete the book.

THE COLOUR RELATIONSHIP BETWEEN CERTAIN PUPAE AND THEIR SURROUNDINGS.

By D. G. Sevastopulo, F.R.E.S.

The following is an account of some experiments carried out during the past few years in Calcutta, whenever time and opportunity permitted. Circumstances did not permit the completion of the work, but the results, incomplete as they are, may be of interest. Three species were employed, *Papilio polytes* L., *P. demoleus* L., and *Danaus chrysippus* L., material being obtained by searching the food-plants in my own and neighbouring gardens fairly systematically throughout the year. The actual account of the experiments is given species by species.

Papilio polytes.—Vague dissatisfaction with the repeated statement that the pupa of this species is green when formed among leaves and brown when on tree-trunks and branches, and that, in captivity, it matches the background on which it is formed within the limits of these two colours, led me to compel larvae to pupate in artificial sites, consisting of 100-size circular cigarette tins enamelled inside in the following colours—white, cream, pink, red, brown, black, blue and green—in total darkness, and in wide glass tubes suspended on a brightly lit verandah.

All *Papilio* larvae behave in the same way just prior to pupation. They cease feeding by about midday, but remain on the food-plant without moving for seven hours or so. During this period they pass pellet after pellet of frass, which is usually rather larger and moister than normal. Finally, usually late in the evening, the final evacuation is made—usually very liquid and containing undigested fragments of leaf. Immediately after this the larva starts to wander. By the following morning it has suspended itself, the change to the pupa taking place some twenty-four hours after the wandering has started.

In these experiments the following procedure was adopted. The larvae were reared, usually from the egg, in glass jars until they were about half grown. They were then transferred to sprays of the food-plant standing in bottles of water and covered with a net sleeve. They were left undisturbed until they had passed the final evacuation referred to above, and were then put into one of the enamelled tins, or other prepared pupating receptacles, which was covered with a piece of glass. The following morning the glass was removed, and the tin was placed in a window with a south aspect with the dorsum of the larva facing the light, and left undisturbed until the pupa was formed in the evening. In the case of the glass tubes and the pupae formed in total darkness the receptacle was either suspended or closed, as the case might be, as soon as the larva was introduced into it, and was left untouched until it was safe to assume that the pupa had been formed.

The pupae formed were either green, exceedingly constant in shade, or mottled brown, varying very slightly and, in some few cases, bearing an emerald-green spot in the centre of the dark discal mark on the wing case, or a rather pale green with the wing cases and abdomen mottled with buff. This latter type I have only seen in captivity; the other three are all found wild.

The original intention was to use two hundred larvae altogether, twenty in

each pupating site, but my departure from Calcutta has prevented this being carried out. The following is a summary of the results so far obtained :

Container.	Green pupae.	Brown pupae without green discal spot.	Brown pupae with green discal spot.	Buff-mottled green pupae.
Black	18	2	–	–
Brown	11	3	1	–
Cream	9	8	2	1
Pink	12	4	2	2
Red	13	3	–	–
White	9	5	2	1
Green	13	2	1	–
Blue	12	3	–	–
Total darkness	9	6	5	–
Glass tube	3	3	–	1

Nine larvae slipped through their girdles, or failed to spin properly, and it was noticed that no fewer than five of these produced brown pupae (the actual figures being, in a red tin one green, one brown, in a green tin two brown, in a blue two green, in a pink one brown, and in a cream one green and one brown). Such fallen larvae are far more active than those that are properly suspended, and this fact suggested the possibility that the colour of the pupa is not influenced by the colour of the pupating site, but by the degree of movement exhibited by the larva after it has started to wander. This hypothesis would provide quite a reasonable explanation for the finding of wild green pupae among leaves and brown ones on the trunks or branches of trees, as the green pupae would have been produced by larvae which wandered little and the brown ones by those that wandered a good deal.

Papilio demoleus.—The experiments carried out with this species were exactly the same as those detailed for *P. polytes*. *P. demoleus* has a far more variable pupa than *polytes* however ; in addition to the green form, which again is very constant in tint, there is a brown form, which varies from pale to dark, a pinkish form, which sometimes is marked on the dorsum with brown, and I have found a wild greyish form, which matched exactly the cement-covered wall on which it was formed. Rather fewer *demoleus* larvae than *polytes* were available, and no *demoleus* larva failed to suspend itself properly or fell through its girdle.

The figures for *demoleus* are as under :

Container.	Green pupae.	Pink pupae.	Pink pupae with brown dorsal marks.	Dark brown pupae.	Pale pinkish brown pupae.
Black	11	–	–	–	–
Brown	10	–	–	–	1
Cream	11	–	–	–	–
Pink	9	1	1	1	–
Red	12	1	–	–	–
White	9	1	–	1	1
Green	12	1	–	–	–
Blue	9	–	–	–	2
Total darkness	12	1	–	6	–
Glass tube	10	–	–	1	–

Statistically these figures are probably not significant, but they do seem to indicate that a brown or blackish background does not tend to produce a higher proportion of brown pupae.

Danaus chrysippus.—The experiments with this species were designed to see whether the larvae were attracted to any particular colour as a pupating site, and whether green pupae were produced on a green background and pink on a pink. There are also records of a white and a yellow form of pupa, but I have never seen either in spite of rearing the species by the hundred. In nature the green form of pupa is usually found among leaves, whilst the pink form is found in other situations.

In these experiments a lidless box, some 8 by 6 by 2 inches, was fitted against the glass of a window facing north-west, so that it was well lighted, but escaped direct sunshine. Strips of card, eight inches by two, were enamelled in inch-wide stripes of black, brown, green, blue, cream, white, pink and red, in several sequences, and these were attached to the inside of the top and back of the box, so that the colours of the top were continued down the back for two inches. As soon as a larva showed signs of approaching pupation, it was placed in one of these boxes and left until pupation was complete. *Chrysippus* larvae usually start wandering about midday, hang up in the evening and change to the pupa early the following morning.

It was noted that there was no special tendency to select the green or the pink stripe for the pupation site, nor was there any tendency to produce more green pupae on the green stripe and pink on the pink. It was noticed, however, that the larvae showed a very definite preference for the end stripes on the cardboard strip irrespective of their colour, i.e. if the stripes had been numbered 1 to 8, 1 and 8 were always the most popular, 2 and 7 next, then 3 and 6, and finally 4 and 5. Presumably the larvae liked the angle formed by the top and side of the box.

Book Notice.

The Sky-scraper Hive. By Father M. Dugat. 8vo. London: Faber & Faber, 1948. Pp. xvi + 78, text illust. Price 8s. 6d.

This first English edition of this work is a translation of the third French edition which appeared in 1947. The translation has been made by N. C. Reeves in co-operation with Father Dugat.

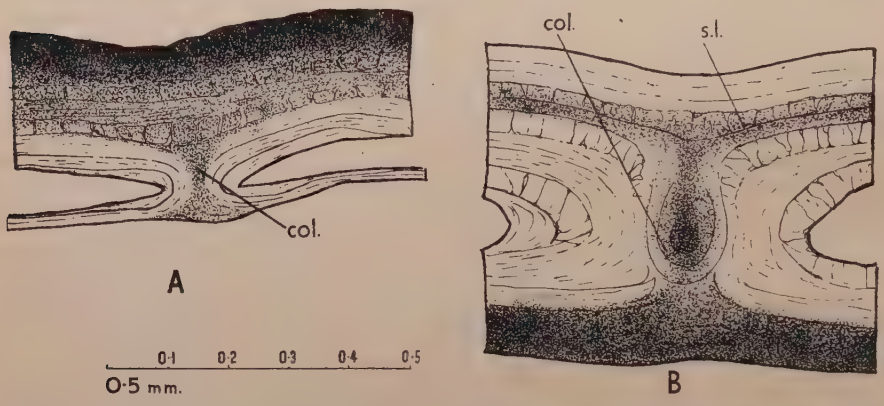
The work describes a new method of intensive bee-keeping perfected by the author in the apiary of the Abbey of Notre Dame des Dombes. Detailed practical instructions are given for this sky-scraper method of bee-keeping, and there are photographs and diagrams which simplify the application of the method.

Besides practical directions, the book contains information which will stimulate and interest all beekeepers.

HARDNESS AND COLOUR OF INSECT CUTICLE.

By M. G. M. Pryor, Ph.D., F.R.E.S.

The hardening of the cuticle of insects probably always involves the formation of compounds coloured brown or black, and in the absence of other factors this determines the colour of the hard parts. In caves, for example, where colour as such cannot be affected by natural selection, the hard parts of insects and other arthropods whose cuticle is hardened with proteins (Arachnida, Chilopoda) are brown or black, whereas Crustacea and diplopods, whose



Figs. A and B.—Transverse sections of elytra of (A) *Onymacris unguicularis* and (B) *O. marginipennis*. *col.*, Columella. *s.l.*, Sclerotin layer.

cuticle is hardened with calcium carbonate, are often white. There are a few apparent exceptions to this rule, of which the most striking was recorded by Schulze in 1922 : the white beetle *Stenocara eburnea* Pascoe (Tenebrionidae). Through the kindness of Dr. K. G. Blair of the British Museum I have been able to examine specimens of *S. eburnea*, and also of the related species *Onymacris marginipennis* Brême and *O. unguicularis* Brême. *Stenocara* has pure white elytra with black legs and prothorax ; *Onymacris marginipennis* has a similar colour scheme, except that the white parts are slightly tinged with yellow ; and *O. unguicularis* is black all over. On examination of the elytra of the white species it was found that the structure is considerably modified, and that they do in fact confirm in a remarkable way the general rule that hard parts are dark.

In transverse sections it appears that the elytra of *Onymacris unguicularis* have the normal structure for a hard elytron (fig. A), with a thick, heavily sclerotized upperside and a membranous underside. In *marginipennis* (fig. B) the upperside is not sclerotized at all except for a thin layer (*s.l.*, fig. B)

some way beneath the upper surface, which appears a pale yellowish brown. The upperside is soft and tough, and the fibrillar chitin of which it is composed shows white, like filter paper. To compensate for the softness of the upperside, the underside is as thick and as heavily sclerotized as the upperside of a typical elytron. If the upperside is partially cleared by wetting it with dilute alcohol the dark underside shows through. I have not been able to section elytra of *Stenocara eburnea*, but from examination of whole specimens the structure seems to be the same, except that the small amount of sclerotin present in the upper layers of *Onymacris* has been completely eliminated.

Reference.

Schulze, P., 1922, *Biol. Zbl.* **42** : 388.

Book Notices.

The Hunting Wasp. By John Crompton. 8vo. London : Collins, 1948. Pp. 255. Price 10s. 6d.

This work opens with a chapter on the method of the hunting wasps, and succeeding chapters are devoted to the caterpillar hunters, the beetle hunters, the bee hunters, the grasshopper hunters, the subterranean hunters, the fly hunters, the spider hunters, and the ant hunters.

An entire chapter is devoted to the various species of *Vespa* (the common wasp), excluding the hornet, which is afterwards dealt with separately.

The style of writing is easy and attractive, and the insects are presented as living creatures in their own setting.

A Revision of the Tribe Scaphytopini (*Homoptera, Cicadellidae*) *in North America.* By Leon W. Hepner. (*Univ. Kansas Sci. Bull.* **31** : 413–541.) 1947.

This paper is a revision of the tribe Scaphytopini in America north of Mexico, and includes the following genera : *Platymetopius* Burmeister, *Japananus* Ball and *Scaphytopius* Ball. The genus *Scaphytopius* is divided into four subgenera—*Scaphytopius* Ball, *Cloanthanus* Ball, *Tumeus* DeLong and *Vertanus* Hepner.

More than 25,000 specimens have been examined. The work includes six plates showing the male and female genitalia of the various species, a bibliography of some 56 titles, and a species index.

A MINUTE BETHYLID WASP OF MEDICAL INTEREST.

By G. A. Walton, M.B., Ch.B.

(*Medical Entomologist, Sierra Leone,* 1943–1946.)

The minute wasps of the family Bethylidae are said normally to use the sting for the purpose of oviposition. Recently, while in Sierra Leone, West Africa, the fact that one species at least can inflict a very painful " sting " was proved beyond doubt.

I first encountered this insect in a rest-house at Kamakui when accompanied by Dr. T. A. M. Nash, who was painfully stung on the back beneath his shirt. The effect was sufficiently dramatic to result in rapid removal of the shirt, revealing three separate slightly raised, pale spots, each surrounded by a red flare. It was natural to suspect a hornet or cantharid beetle, and surprising to find only the remains of a very small soft ant-like insect.

Later, in my house in Freetown, I was repeatedly and most painfully stung on the wrists and legs while sitting quietly reading during the early evening. The insect runs rapidly, resembling a dark brown ant, but the abdomen is longer and more mobile and the sting disproportionately large. It is so small as to pass unnoticed unless trapped between the skin and clothing, when it immediately inflicts as many as four separate stings, the effects of which are felt for several hours afterwards.

About this time complaints were received from several Government Offices to the effect that " mosquito bites " were causing trouble during the daytime. Investigations failed at all times to reveal any mosquitoes or other biting or stinging insect, and it is possible that this little wasp may have been responsible, and if so then the complaints would be fully justified !

Africans of the Timani tribe have no small respect for it, and call it N'tempe, and say they are stung by it when working in the pepper plantations at harvesting time, but I was always stung when in a house.

Mr. G. E. J. Nixon has kindly identified specimens that were captured immediately after stinging me. These were caught in a house at Brookfields, Freetown, from March to May, 1946, and all were *Scleroderma wollastoni* Westwood. Examples have been deposited in the British Museum and in the Department of Entomology, London School of Hygiene and Tropical Medicine.

ECOLOGICAL AND BIOLOGICAL OBSERVATIONS ON SOME COPROPHAGOUS SEPSIDAE (DIPTERA).

By M. Hafez, M.Sc., Ph.D., F.R.E.S.

(*Department of Entomology, Faculty of Science, Fouad I University, Cairo.*)

In an earlier paper (Hafez, 1939) the present author recorded four species of Sepsidae which breed in dung in Egypt, and described the life-history of one of them, *Sepsis impunctata* Macquart. Since then more species of coprophagous Sepsidae have been recorded (Hafez, 1947) and more observations on their biology have been made in three localities near Cairo in 1940–42. The results obtained are given in the present paper, which was prepared in the Zoological Laboratory, Cambridge.

Very little attention has been paid to the biology of Sepsidae. With the exception of Ole Hammer's work (1941) on flies in Denmark, which included valuable information on the biology of some species of Sepsidae, no detailed biological account seems to have been given by previous workers. Brief notes on the biology are, however, included in the works of Wahlgren (1905–22), Séguy (1923), Ringdahl (1924), Duda (1925), Goetghebuer and Bastin (1925), etc. The phenomenon of swarming has been reported and described in some species by Donisthorpe (1943), Coe (1943) and Thorpe (1947).

The following species of coprophagous Sepsids occur in Egypt :

Saltelliseps niveipennis Becker.
S. niveipennis Becker var. *robusta* Duda.
Sepsis fissa Becker.
S. thoracica Robineau-Desvoidy.
S. thoracica Robineau-Desvoidy var. *consanguinea* Villeneuve.
S. lateralis Wiedemann.
S. fragilis Becker.
S. impunctata Macquart.
S. hyalipennis Macquart.
Lasiosepsis hirtipes Becker.

Habits of the Adults.

Breeding Media.

These insects are dominant members of the insect fauna of dung. They are commonly seen in huge numbers dancing and moving briskly about on the fresh dung and periodically swinging their wings and abdomen.

Field observations and laboratory experiments have clearly demonstrated that these flies breed mainly in cow and buffalo dung, which seems to attract the ovipositing females more than any other kind of dung. Horse manure, on the other hand, does not generally attract these flies. When offered the choice of cow and horse dung these flies persistently avoided the latter. Table I shows typical results of five breeding experiments in three species.

TABLE I.—*Total Number of Flies Emerging in Five Experiments from Different Kinds of Dung Exposed for Ovipositing Females for Two Hours (from 10–12 a.m.) in the Open. In each experiment four equal masses (each is a pound in weight and 400 sq. c.c. in surface area) of fresh cow-, buffalo-, horse- and pig-dung were used. Temperature during all experiments was 26–28° C.*

Species.	Cow dung. Number of flies.	Buffalo dung. Number of flies.	Horse dung. Number of flies.	Pig dung. Number of flies.
Saltelliseps niveipennis	3972	2918	8	944
Sepsis lateralis	2715	3011	0	614
S. thoracica	2021	2129	0	223

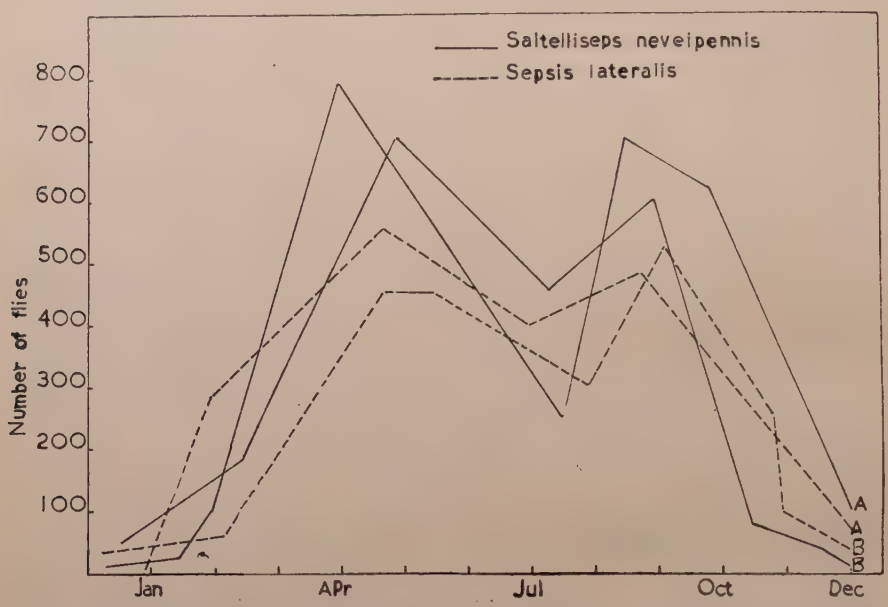


FIG. 1.—Number of flies emerging from equal masses (each is one pound in weight and 400 sq. c. in surface area) of cow dung after two hours' exposure in the open (from 10–12 a.m.) to ovipositing females in two localities, A and B. The results are the average of ten experiments repeated in every month in 1941. Temperature during all experiments was 25–28° C.

Seasonal Prevalence.

These flies are generally met with all the year round, but *Saltelliseps niveipennis*, *Sepsis lateralis* and *Sepsis thoracica* are more common than the other species. From April to October these three species show themselves in great abundance, reaching their maximum numbers in the spring (April and May) and in the autumn (mainly in September). During these seasons breeding activity is at its highest. Males and females are seen in huge numbers on the dung *in copula* and the eggs are laid in great numbers.

In January and February the number of flies visiting the dung falls considerably, and the flies may disappear completely on the coldest days when the atmospheric temperature is below 10° C.

Laboratory breeding experiments have also shown that the greatest numbers of *Saltelliseps niveipennis* and *Sepsis lateralis* emerged in April, May and September (fig. 1).

Appearance on the Dung.

Sepsids are the first insects to appear on freshly deposited cow- or buffalo-dung. On several occasions they were attracted to the dung one minute after deposition in the field. Their numbers grow gradually within a short time. For instance in *Sepsis lateralis* as many as 20 flies could be seen on a fresh dropping (about 600 sq. c.c. in surface area and about 5 c.c. thick) one minute after deposition. This number was rapidly increased to about 400 flies at the end of 15 minutes. This relatively large number was, however, maintained for more than an hour, after which a gradual fall became obvious, and by the end of the sixth hour practically no flies were seen on the dung. Probably the crust which forms on the surface of the dung renders it less odoriferous, and so less attractive to the ovipositing females. The rate at which the crust is formed largely depends on the season of the year and the size of the dung mass. During the summer (atmospheric temperature may be as high as 45° C. in the sun, and a few degrees lower in the shade) the crust may be formed in a few hours, while in the spring and autumn it may take several hours.

Owing to the high water content of cow dung, which is about 85–90 per cent. (Hafez, 1939 : 244), and to the formation of the surface crust, which lessens the rate of evaporation, the dung remains moist from the inside for a relatively long time. When this soft part becomes exposed by removing the crust, it still shows a marked ability to attract flies for feeding and ovipositing. This ability was, however, reduced to a minimum or disappeared completely in 3-days-old dung. This is most probably due to the dung losing its characteristic smell and undergoing some chemical changes, etc., as it advances in age.

Life-History : General.

Mating.

This phenomenon was studied in *Sepsis lateralis*. Under natural conditions, mating usually occurs on the dung. When the flies arrive on the dung, the males appear first, most of them settling on the edge of the dung mass, and a few on the middle. They swing their wings in the way characteristic of Sepsidae. Shortly afterwards the females appear, which are soon approached by the males. The mode of approach of the male to the female is closely similar to that of *Sepsidimorpha* (Hammer, 1941). The male first stands at right angles to the female with their heads close to each other, but in less than a few seconds their bodies become parallel to one another, and then the male jumps over the female and copulation begins on the dung. Scores of these flies are commonly seen *in copula* on fresh dung. In that condition the pairs stand still save for the males swinging their wings from time to time. These pairs may remain *in copula* for 1–15 minutes on the dung.

The Egg and Egg-laying.

The eggs are laid on the surface of the dung mass ; most of them are, however, deposited near the edges, forced into the dung substance, leaving the

greater part of the long respiratory appendage projecting from the surface. Every few seconds during oviposition the female moves the tip of its abdomen upwards, probably to pull the respiratory appendage after the egg has been laid. The same observation was recorded in *S. cynipsea* (Hammer, 1941).

Eggs are deposited in small batches of 3 to 20 eggs. The egg of *S. lateralis* is about 0·5 mm. long and 0·14 mm. broad, oval in shape; the posterior end is nearly twice as broad as the anterior end. The colour is creamy-white, the surface is reticulately sculptured. The egg has a long respiratory appendage or flagellum at its anterior end. It is nearly four times the length of the egg. On hatching the egg splits along two small sutures situated anteriorly on either side.

The egg hatches about ten hours after deposition at 27–28° C.

The Larval Stage.

When newly hatched the larvae usually occur around the periphery of the dung mass near the surface. As they advance in age, the larvae burrow in the breeding medium, but remain more or less confined to the upper part of the mass, with their posterior spiracles mostly directed towards the surface.

The frequent occurrence of larvae near the surface is probably due to the favourable temperature as well as to the rich oxygen supply prevailing in this region of the dung mass. The rich supply of oxygen is due to the formation of a hollow space just below the crust. This space communicates with the outside atmosphere by means of the numerous holes made in the crust by the Scarabaeid beetles (e.g. *Aphodius*, *Onthophagus* and *Oniticellus*) and by the Hydrophilid and Histerid beetles (e.g. *Sphaeridium*, *Hister* and *Saprinus*). As the upper region becomes old and less nutritive the larvae, which by then have reached the third stage, burrow a little downwards, making access to the still moist dung below.

The larvae are dung feeders, but the actual substances on which they feed are not definitely known. It is very probable that such coprophagous larvae feed on the micro-organisms which are abundant in the dung (Baumberger, 1919, and Hammer, 1941).

The average durations in hours of the three larval stages in the three species at 26–28° C. are as follows:

Larval stage.	*Salt. niveipennis.*	*S. lateralis.*	*S. thoracica.*
1st stage	22	20	22
2nd stage	34	38	36
3rd stage	40	46	43
Total	96 hours	104 hours	101 hours

The Pupal Stage.

Unlike many other dung insects, most of the Sepsid prepupating larvae occur in the upper part of the dung mass below the surface crust. In that locality the pupae are abundantly met with. No pupae were found at the bottom of the dung mass or below it on the ground. Hammer (1941) recorded the abundant occurrence of the pupae of some sepsid species (e.g. *Sepsidimorpha* sp. and *Pandora* sp., etc.) from the same locality.

The pupal stage in *Salt. niveipennis*, *S. lateralis* and *S. thoracica* lasts about 48 hours at 27–28° C.

Predators.

The larvae have several enemies in their natural habitat. Of these the most serious are the Histerids (e.g. *Hister bimaculatus* L. and *H. scutellaris* Erichson) and the Staphylinids (e.g. *Philonthus quisquiliarius* Gyllenhall, *P. discoideus* Grav., *P. concinnus* Grav., *Aleochara bipustulata* L., *A. moesta* Grav., etc.). These beetles are predaceous in both the adult and larval stages. They attack the fly eggs and larvae of all ages. Ten eggs of *S. thoracica* were readily devoured by one *Philonthus* beetle in less than 5 minutes. On several occasions first, second and third stage larvae of the same fly were fiercely attacked by *Hister* larvae. The latter are very active in the dung, and their strong curved mandibles bespeak a ferocity of habit. The beetle larva rushes on the relatively slow fly larva, and by means of its sharp mandibles makes an incision, usually near the middle, and then apparently sucks the juice of the victim's body. One *Hister* larva (8 mm. in length) was able to feed on 30 first stage larvae of *S. thoracica* (each 0·8 mm. to 1·1 mm. in length) in about 8 hours.

In order to find out to what extent these predaceous beetles attack the sepsid fly larvae or eggs, a series of simple laboratory experiments were carried out, and in which eggs, 1st, 2nd and 3rd stage larvae of *S. lateralis* were placed in breeding jars containing small quantities of one-day-old cow dung with beetle larvae or adults. In each experiment 20 fly larvae or eggs were placed with one beetle larva or one adult. The duration of each experiment was two hours at 26–28° C.

The results of these experiments have shown that *Hister* larva seems to be the most ferocious predator. It severely attacked the fly larvae at all stages. *Philonthus* larva, on the other hand, is much inferior in this respect. Both larvae generally showed some indifference to the presence of eggs. These latter were, however, readily devoured by the adult beetles, which in the meantime attacked a relatively small number of first stage larvae, *Hister* being more predaceous than *Philonthus*.

In their natural habitat these predators play an important part in keeping down the number of Sepsid flies emerging from the dung, as they prey on their eggs and larvae. But it is probable that the total destructive effect of *Philonthus* is much greater than that of *Hister*, although the individual devouring capacity of the latter is higher in the adult and larval stages. This is probably due to the fact that *Philonthus* larvae and adults are much more abundant than *Hister* in the dung mass. Also the appearance of *Hister* comes next to that of *Philonthus* in the ecological succession of dung insects (Hafez, 1939 : 248), and the developing larvae of the former find themselves somewhat behind the fly larvae in development. Furthermore, *Philonthus* larvae are more active in the dung than those of *Hister*.

Acknowledgments.

The author wishes to express his sincere thanks to H. C. Efflatoun Bey, Professor of Entomology, Fouad I University, Cairo, for his valuable help and encouragement, and to Dr. W. H. Thorpe and Dr. J. Smart, Zoological Laboratory, Cambridge, for reading the manuscript.

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THE NYMPH OF *ANACRONEURIA AROUCANA* KIMMINS. (PLECOPTERA, PERLIDAE).

By H. B. N. Hynes, Ph.D., A.R.C.S., F.R.E.S.

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During 1941 and 1942, while a Colonial Agricultural Scholar at the Imperial College of Tropical Agriculture, Trinidad, B.W.I., I made a number of collections in streams, pools and swamps with the object of investigating the Plecoptera and aquatic Hemiptera of the island. Most of my collections were made within a few miles of St. Augustine and Port of Spain, and the number of stations I was able to work was limited by time and the availability of transport.

Surprisingly, although thorough searches were made in sixteen localities of the type in which one would normally expect to find stoneflies (i.e. stony bottomed rapid-running water), stonefly nymphs were only found in two of them, and they were not particularly abundant in either. No imagines were taken in the field, but a male and two females were reared from nymphs taken in the Arouca River, and two similar adults were seen near the locality on a tributary of the Maracas River, where nymphs were also found. It was, unfortunately, impossible to catch these adults as they flew actively, and the vegetation bordering mountain streams in Trinidad is difficult to penetrate without using a cutlass. I am, however, confident that they were of the same species as those from the Arouca River, because the bright saffron yellow body and dark wings of the species make it a conspicuous insect. The nymphs from the two localities also appear to be identical. I therefore assume that all the Plecoptera I collected in Trinidad belong to one species, but I was unable to confirm this because of the difficulty of rearing the nymphs to maturity, without adequate laboratory facilities, in the hot humid climate of St. Augustine.

Mr. D. E. Kimmins of the British Museum has kindly examined the three specimens that I was able to rear and has described them as a new species, *Anacroneuria aroucana* (Kimmins, 1948). I am most grateful to him for this assistance.

The nymph of *A. aroucana* is described below and compared with other described nymphs of species in the sub-family Acroneuriinae. I have also noted down the few facts of the ecology of the species that I was able to ascertain.

Description of Nymph.

Size of full-grown nymph, male 9·5–10·0 mm., female 11·0–12·5 mm.

General colour brown with yellow pattern above, pale yellow below. Legs and appendages yellow, legs slightly darker above.

Head wide, moderately flattened, without occipital ridge. Anterior ocelli absent, posterior ocelli large and kidney-shaped. M-line smoother and slightly paler than the surrounding area. Occipital suture indistinct. Colour dark brown in front, except for

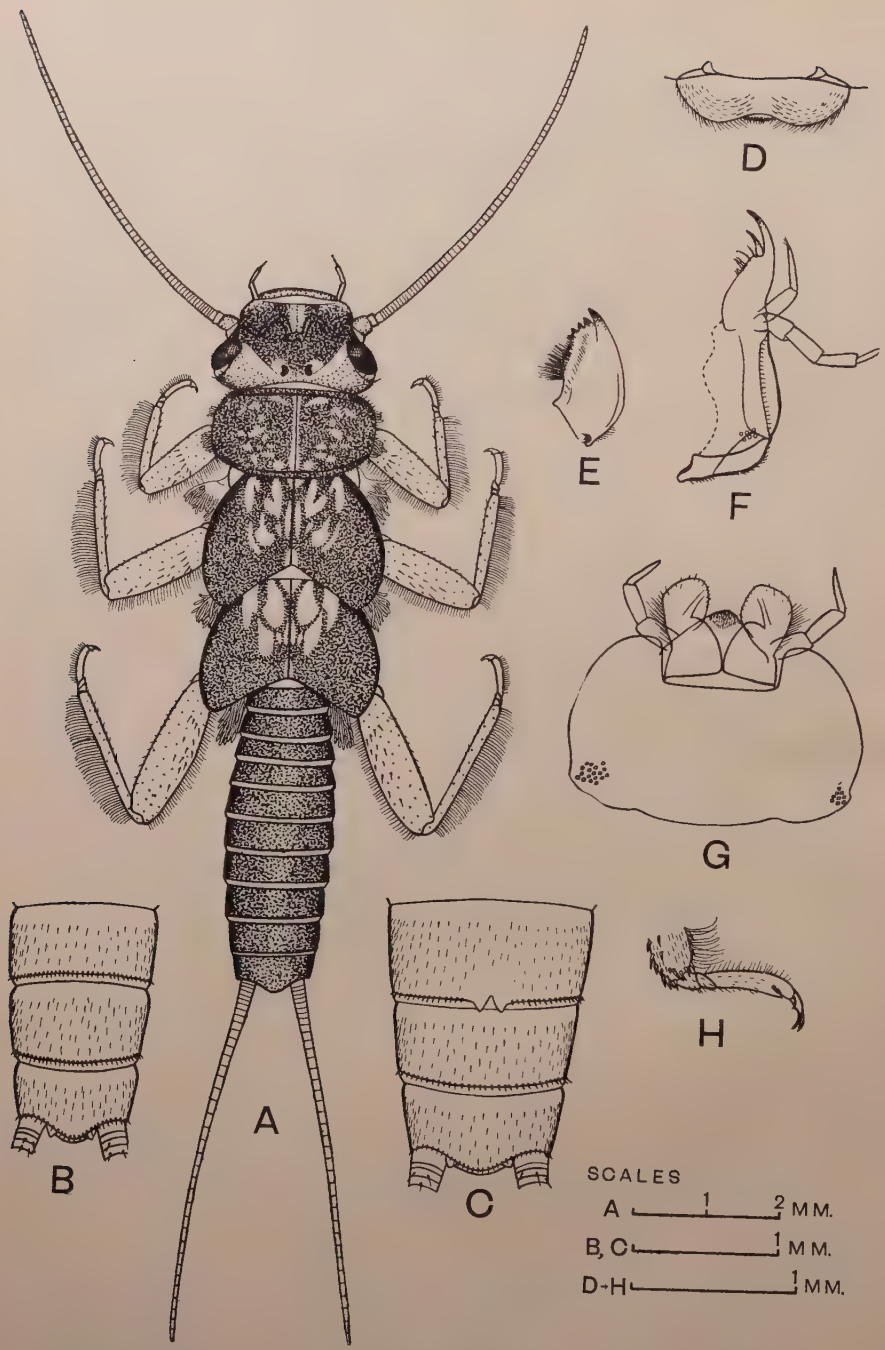

FIG. 1.—*Anacroneuria aroucana*. A, full-grown male nymph; B, tip of full-grown mael abdomen in ventral view; C, tip of full-grown female abdomen in ventral view; D, labrum in dorsal view; E, right mandible in dorsal view; F, right maxilla in dorsal view; G, labium, with hypopharynx attached, in ventral view; H, mid-tarsus. All drawn with the aid of a projector.

Note.—In order to show the notal patterns fig. 1A is rather more darkly shaded than the specimens.

membrane behind labrum, with a transverse yellow band behind the occipital suture and in front of the posterior ocelli (fig. 1A); posterior part of head pale brown, in some specimens little darker than the transverse yellow bar. *Mouth parts* and antennae yellow. Labrum transverse (fig. 1D). Mandibles symmetrical, each with 5 teeth and a well-developed brush of bristles (fig. 1E). Maxillae with movable tooth on lacinia and few masticatory bristles, and with reduced fifth joint on the palp (fig. 1F). Labium with narrow mentum and wide shield-shaped sub-mentum, palps narrow and pointed (fig. 1G). Both maxillae and labium bear groups of placoid sensillae, and the palps of both are without hairs. *Thorax* wide and moderately flattened. Pronotum elliptical, with well-marked groove. Wing pads well developed in both sexes. Nota brown with characteristic and constant patterns of yellow spots (fig. 1A). *Gills* present. Bunches of filamentous gills present posterior to the pleura of each thoracic segment (gills I, II and III), and double bunches of gills present above the coxae of the first thoracic segment (gills C_1). No supra-coxal gills on segments II and III (gills C_2 and C_3) and no anal gills. *Legs* with moderately flattened femora. Femoral line inconspicuous. Tarsi with 1st and 2nd segments small and sub-equal (fig. 1H). Claws strong and toothed at the base. *Abdomen* not flattened. Segments 1 and 2 divided into tergum and sternum, segments 3–10 forming complete rings. Sub-anal plates small and inconspicuous (figs. 1B and C). Cerci stout and long, each segment with an unevenly developed whorl of bristles. Colour of abdomen brown above, paler below; without pattern. The sexes are distinguishable because in the female the posterior edge of the 8th abdominal sternum is produced into two bristleless triangular lobes (fig. 1C); in the male (fig. 1B) this edge is entire and there is no interruption in the line of bristles. *Hairs and bristles:* The entire dorsal surface, except for the centres of the nota, is covered with fine, closely applied, clothing hairs; the ventral surface of the abdomen, except anteriorly, is similarly covered. Behind the eyes, round the sides of the nota, on the posterior borders of each abdominal segment, except ventrally on the anterior segments, are fringes of weak bristles. Mouth parts and antennae with few bristles and no clothing hairs. Legs covered with clothing hairs and with scattered bristles; femora, tibiae and tarsi each with a posterior fringe of long hairs (figs. 1A and H).

The young stages are similar in general shape. At 2·5 mm. the colour is uniform pale yellow without pattern, no ocelli are visible, and only gills I, II and III are present each containing 8–9 filaments. At 3·0 mm. ocelli and pattern are still not visible, but the number of filaments in gills I, II and III has increased to about 20 per bunch. At 5·0 mm. the colour is darker and the pattern faintly visible; ocelli and gills C_1 have appeared, the latter containing each about 14 filaments. At 7·0 mm. the pattern is more distinct, and the gills fully developed; the wing pads are beginning to develop. At 7·5 mm. the females begin to be distinguishable by a simple break in the row of bristles on the 8th abdominal sternum. At 10·0 mm. the 8th sternum of the females shows a V-shaped notch, and in larger specimens the characteristic triangular lobes are more or less developed on each side of the notch.

The description is made from 28 nymphs ranging from 2·5–12·5 mm. in length from front of head to tip of abdomen, collected in Trinidad, B.W.I.: Arouca River, 22 and 29. xi. 1941 and 25. iv. 1942 and Tributary to Maracas River, 17. xii. 1941 (*Hynes*). Most of these nymphs have been presented to the British Museum (Natural History).

Comparison With Other Described Acroneuriine Nymphs.

Anacroneuria sp. from Columbia (Needham and Broughton, 1927) differs, as described, from *A. aroucana* in several respects, of which the most important are the absence of gills, which are neither mentioned nor figured, the pronotal pattern, the absence of a well-defined pattern on the meso- and metanotum,

and the black mark on the tip of femur. Other differences which appear from the description and figures are the shape of the ocelli, which are not kidney-shaped, the median notch in the labrum, the globular 5th segment of the maxillary palp and the rounded tip of the labial palp. It would seem, therefore, that considerable differences are likely to be found between nymphs of different species of this genus. It appears, however, highly probable that all species will in fact be found to possess gills, as do most other described Acroneuriine nymphs, and that these were merely overlooked by Needham and Broughton while making their description. Possibly their material was dried, not preserved in liquid, in which case it is quite probable that the gills were retracted and shrivelled, and so easily missed. If this was so it may account also for some of the differences in the mouth parts.

Acroneuria spp. Nymphs of several species of this genus have been described from North America (Claasen, 1931, Frison, 1935, 1937 and 1942, Neave, 1933), and one species has been described from Japan (Kohno, 1937*b*). Unfortunately this last description is in Japanese, and from the figures the nymph appears to differ radically from all other described nymphs of the genus in the complete absence of gills. All the other described species differ from *A. aroucana* and *Anacroneuria* sp. in the possession of a median ocellus, and all apparently possess gill-bunches I, II and III and gill-bunches C_1, C_2 and C_3. Frison's figure (1935) of *Ac. internata* (Walker) clearly shows all six pairs of gill-bunches, and he has nowhere indicated that any species possesses fewer than this. Similarly Claasen indicates that all these gill-bunches are present in the eight species he describes. He, however, regards gill-bunches C_1, C_2 and C_3 as being each composed of two bunches in most species, and so states that 9 pairs of gill-bunches are present. He admits that the two halves are often difficult to distinguish, and for this reason I think it better to regard them as double-bunches and not as two separate bunches. I have examined nymphs of three of the species described by the late Dr. Claasen, which he very kindly gave to me some years ago, and find that all 6 bunches of gills are present. Some of the described species also possess anal gills and/ or an occipital ridge. These latter characters combined with the colour pattern, which in several species is remarkably similar in general outline to that of *A. aroucana*, serve to distinguish the species within the genus. The mouth parts are similar to those of *A. aroucana* and appear to show no good specific characters. All species of *Acroneuria* are large, most being 15–25 mm. long when full-grown ; only *Ac. georgiana* (Banks) is often smaller than 15 mm.

Classenia arctica (Klapálek) is described by Frison (1942). The nymph is large and closely resembles *Acroneuria* ; Frison expresses doubt as to its generic distinctness. It appears from his figure to possess all six pairs of thoracic gill-bunches, as well as anal gills, an occipital ridge and three ocelli. It is therefore clearly separable from *A. aroucana*.

Atoperla ephyre (Newman) is described by Claasen (1931) and Frison (1935) from North America. It resembles *A. aroucana* in its small size (up to 12 mm.), and the absence of the anterior ocellus ; its mouth parts are also similar. It differs, however, in the presence of small anal gills and the absence of any colour pattern. It appears also to differ in the presence of all six pairs of thoracic gill-bunches, although this fact is not stated in the descriptions, and is not quite clear from the figures. I have, however, examined adults of this

species, kindly given to me by Mr. J. F. Hanson, and have been able to detect vestiges of all but gill-bunch III, and this gill-bunch is clearly shown in Claasen's figure.

It would seem, therefore, that the most important characters in which Acroneuriine nymphs differ from one another are the number of ocelli, the number and position of the thoracic gill-bunches, the anal gills, the occipital ridge and the colour pattern. It is interesting to notice that all described nymphs of the sub-family NEOPERLINAE are without the anterior ocellus and some have an occipital ridge (Claasen, 1931, Frison, 1935, Kohno, 1937*a*, Barnard, 1934), and that one form at least, which has been placed in the genus *Neoperla*, has the same arrangement of thoracic gills as *A. aroucana* (Lestage, 1916). These facts indicate that the two sub-families ACRONEURIINAE and NEOPERLINAE are very closely allied. They also indicate characters to which special attention should be paid in future descriptions of Perlid nymphs, which are too often confined to details of the colour pattern. It should, however, be noted that the number of gill-bunches may increase with age, as is shown above for *A. aroucana*, and as occurs in *Perla* (Hynes, 1941). It seems probable that thoracic gills will be found to occur on the nymphs of all species of PERLIDAE (*s.s.*).

ECOLOGICAL NOTES.

A. aroucana would appear to be the only species of Plecoptera that occurs in Trinidad, and it seems that it is not an abundant species there. The only other specimens that I have seen were two damaged nymphs, apparently of the same species, collected by Dr. E. McC. Callan from Santa Cruz in 1938; the late Dr. A. M. Adamson, who spent several years in Trinidad, knew of no other records. In this connection it is of interest to note that I was unable to find any Plecoptera in the neighbouring island of Tobago during a short visit in April 1942, when four apparently suitable streams were examined.

In November, 1941, nymphs taken in the Arouca River had a size range of 2·5 to 12·5 mm., the larger specimens being ready to emerge, and the smaller much less than half-grown. The adults reared in captivity emerged on 30th November and 1st and 4th December, and adults were seen on the wing near a tributary of the Maracas River on 17th December. In April, 1942, during the brief annual dry season, when the river was low, only three nymphs could be found, and these were all less than half-grown. It appears, therefore, that emergence does not occur during the dry season (April), but that it may be continuous during the rainy months. An unlikely alternative is that the nymphs grow very slowly, taking two or more years to become ripe, and that emergence normally occurs in November to December. The available data are, however, inadequate to settle this point.

The two localities in which the nymphs were found were both stony streams, one 2 yards wide, the other about 20 yards wide. In the smaller (tributary to Maracas River) the stream bed was fairly stable and covered with a coat of algae, but in the larger (Arouca River) the stream-bed was loose and shifting, and no vegetation was visible even on several huge boulders 6–8 ft. in diameter which were fixed in the stream bed. In neither was the water deeper than 1 ft., but probably, during spates, the Arouca River rises several feet. In both localities there was no silt, and the only vegetable debris was a few leaves

of bamboo. The nymphs occurred clinging to the undersides of stones, together with nymphs of Ephemeroptera and Odonata, Psephenine larvae (Dryopidae) and Trichoptera larvae (Hydropsychidae, Philopotamidae, Hydroptilidae and Leptoceridae).

The only noticeable ways in which these two localities differed from the 14 others in which Plecoptera were not found were that they were swift and completely unsilted, the water was shallow and comparatively free of vegetable debris, there was no lime deposit on the stones, and they were largish streams, some of the others being very small. Perhaps some or all of these are factors determining the distribution of the species. Noticeably the Aripo River, which deposits a thick crust of calcium carbonate on its bed, has a very meagre fauna. Hora (1936) found similarly that in India streams which deposit calcium tend to be without certain types of organism.

All rapid stony streams in Trinidad flow through dense rain forest, or the rather similar cacao plantations, and often the trees tower 300 ft. above them and shut out most of the direct sunlight. Along the banks there is usually a dense wall of impenetrable vegetation. The streams, therefore, differ very considerably from the type of habitat in which stoneflies abound in temperate climates, and this together with the hot humid climate may account for the paucity of Plecoptera, an order within which the species are usually stenothermic.

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INDEX

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